SUB NEW SPEC PAPER #5

METHOD AND APPARATUS FOR DETERMINING A RECORDABLE POSITION OF A WRITABLE DISK

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to method and apparatus for recording new data in a writable disk after a previous recording to the disk is interrupted abnormally.

2. Description of the Related Art

FIG.1 is a simplified block diagram of a conventional optical disk device for recording and reproducing data to/from a writable disk such as an once-recordable disk CD-R and a rewritable disk CD-RW. The disk device of FIG.1 comprises a digital recording signal processor 4b for converting input data into recording-formatted data as adding additional data such as error correction codes, a channel bit encoder 11 for converting the recording-formatted data into EFM-formatted bit stream, a writing driver 12 for yielding a writing current according to an input bit stream, an optical pickup 2 for recording signals corresponding to the writing current onto an optical disk 1 and reproducing recorded signals from the optical

disk 1, an R/F unit 3 for yielding servo error signals TE and FE, and binary signals through combining the reproduced signals from the disk 1, a digital reproducing signal processor 4a for restoring original data from the binary signals, a sled motor 9 for moving the pickup 2 radially, a spindle motor 10 for rotating the disk 1, a driving unit 8 for driving the motors 9 and 10, a servo unit 5 for controlling the driving unit 8 and the pickup 2 based on the servo error signals TE and FE, a microcomputer 6 for controlling overall operation of the servo unit 5, digital signal processors 4a and 4b, and the writing driver 12 in order to record and reproduce data, and a memory 7 for storing data for the microcomputer 6 to use for supervising operation.

FIGS. 2 and 3 depict recording area format and an example of recorded data for an once-recordable disk CD-R or a rewritable disk CD-RW. The writable disk is partitioned, as shown in FIG.2, into a power calibration area (PCA), a program memory area (PMA), and one or more sessions, each consisting of a lead-in area, a program area, and a lead-out area.

The PCA is used for writing data experimentally to determine an optimal writing power, and the PMA is reserved for recording information such as position and size of each recorded track which is data group recorded continuously without stop. Each track recorded in the program area is separated by a pause section which is corresponding to about 2 second reproduction time.

The lead-in area has information on next recording position, that is, lead-in area position of neighboring next session. Therefore, when data recording is requested, a final recording position, that is, next recordable position is detected easily and quickly through reading the lead-in area of a last session which was closed before.

FIG. 4 is a flow chart of writing new data adjacently to

previously-recorded data. The conventional data writing method of FIG. 4 to be conducted by the disk device of FIG. 1 is described.

When a user requests new data to be recorded in an inserted disk 1, the microcomputer 6 sets its mode to recording mode (S10), conducts an optimal power calibration (OPC) as recording and reproducing test data to/from the PCA, and sets an optimal writing power determined through the OPC into the writing driver 12 (S11).

After that, the microcomputer 6 reads position and size information, which is recorded in the PMA, about recorded tracks (S12), and searches for the first lead-in area, the second, and the third, in turn based on the PMA information (S13). For example, supposed that tracks 1 and 2 belong to the first closed session, tracks 3 and 4 belong to the second closed session, and tracks 5 and 6 are recorded next to the second closed session as shown in FIG. 5, the microcomputer 6 reads out position information of the second lead-in area 'LIA2' from the first lead-in area 'LIA1', and knows the next recording position, that is, the position of track 5 from the second lead-in area 'LIA2'.

Since the program area containing the tracks 5 and 6 is not closed into a session (S14), the microcomputer 6 examines the PMA information to know how many tracks are recorded in the disk 1 (S15), and locates final recorded track 6 based on the PMA information (S16). Then, the microcomputer 6 controls the digital recording signal processor 4b and the servo unit 5 to record new data separated a pause section off from the track 6. If all of the new data are recorded, the microcomputer 6 designates just-recorded data block as track 7, creates information on the recorded position and size about the track 7 and writes it in the PMA (S17).

Some time later, if the tracks 5 to 7 are requested to be closed in a session (S18), the microcomputer 6 groups the

tracks 5 to 7 into the third session, writes necessary information in the secured third lead-in area 'LIA3', and secures the third lead-out area 'LOA3' next to the last track (S19). After that, the above-explained recording operation will be conducted or not according to a user's request.

However, during the recording operation, a servo control may be failed due to a mechanical shock or a data buffer may be underruned, which causes the current recording operation to stop abruptly without writing track information or lead-in information. Therefore, the PMA information may represent real-recorded tracks wrongly or the lead-in area may contain invalid information.

For a writable disk suffered such a recording fail, it is impossible to detect last recording position exactly, so that new data may be overwritten onto previous data or unwritten area may arise between last recorded track and new recorded track. If previous data was overwritten by the new data, the previous data would be lost.

Especially, if the writable disk is once-writable one, the new recorded data as well as the previous data are damaged together when the previous data are overwritten since the surface is burned while recording and it can not be restored to unburned state.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a method and an apparatus for determining a recordable position of a writable disk such as an once-recordable disk and a rewritable disk, which detects a recordable position from recording information, and verifies the detected recordable position to know whether it is the last position of actually-recorded data or not by examining recorded state changed from written data.

A method of determining a recordable position of a writable disk according to the present invention, reads data recording information of the writable disk, examines whether an area after a recordable position indicated by the read data recording information has recorded data or not, and changes the recordable position to other position for new input data based on the examination result.

Another method of determining a recordable position of a writable disk according to the present invention, checks whether a previous recording has been done normally, examines a recording area affected by a writing beam during the previous recording according to the checked result, and determines a recordable position for new input data based on the examination result.

A disk recording/reproducing apparatus to which the above method according to the present invention is applied, comprising a pickup of writing input data and reading the written data to/from a writable disk; a moving means of moving the pickup across the writable disk; and a controller of controlling the moving means to move the pickup, when recording of new data is requested, to a recordable position indicated by data recording information which was updated after previous data recording, checking whether or not recorded data exists after the indicated recordable position through examining the state of a recording surface of the writable disk, and changing the recordable position for the new data to other position based on the checked result.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention, illustrate the preferred embodiments of the invention, and together with the description, serve to explain the principles of the present

invention.

In the drawings:

FIG.1 is a simplified block diagram of a conventional optical disk device for recording and reproducing data to/from a writable disk;

FIGS. 2 and 3 depict recording area format and an example of recorded data for an once-recordable disk CD-R or a rewritable disk CD-RW;

FIG. 4 is a flow chart of writing new data adjacently to previously-recorded data;

FIG. 5 describes an example of recorded data of a writable disk and a recording procedure to the disk;

FIG. 6 is a block diagram of an optical disk device to which a recordable position determining method according to the present invention is applied;

FIG. 7 is a flow chart of determining a recordable position of a writable disk according to the present invention;

FIG. 8 describes an example of recorded data and a recording procedure according to the present invention;

FIG. 9 describes another example of recorded data and a recording procedure according to the present invention;

FIG. 10 describes another example of recorded data and a recording procedure according to the present invention; and

FIG. 11 describes another example of recorded data and a recording procedure according to the present invention.

DETAILED DESCRIPTION OF THE PREFFERRED EMBODIMENTS

In order that the invention may be fully understood, preferred embodiments thereof will now be described with reference to the accompanying drawings.

FIG. 6 is a block diagram of an optical disk device to which a recordable position determining method according to the present invention is applied. The disk device of FIG.6 comprises

a digital recording signal processor 34b for converting input data into recording-formatted data as adding additional data such as error correction codes, a channel bit encoder 41 for converting the recording-formatted data into EFM-formatted bit stream, a writing driver 42 for yielding a writing current according to an input bit stream, an optical pickup 32 for recording signals corresponding to the writing current onto an optical disk 1 and reproducing recorded signals from the optical disk 1, an R/F unit 33 for yielding servo error signals TE and FE, and binary signals through combining the reproduced signals from the disk 1, a digital reproducing signal processor 34a for restoring original data from the binary signals, a sled motor 39 for moving the pickup 32 radially, a spindle motor 40 for rotating the disk 1, a driving unit 38 for driving the motors 39 and 40, a servo unit 35 for controlling the driving unit 38 and the pickup 32 based on the servo error signals TE and FE, a microcomputer 36 for controlling overall operation of the servo unit 35 and digital signal processors 34a and 34b, and the writing driver 42 in order to record and reproduce data, and checking the reproduced EFM-formatted binary signal from the R/F unit 33 to know whether a corresponding area has recorded data or not, and a memory 37 for storing data for the microcomputer 36 to use for supervising operation.

FIG. 7 is a flow chart of determining an actual recordable position of a writable disk according to the present invention. The method of FIG. 7 embodying the present invention to be conducted by the disk device of FIG. 6 is described in detail.

When a user requests new data to be recorded in an inserted disk 1, the microcomputer 36 sets its mode to recording mode (S30), conducts an optimal power calibration (OPC), and sets an optimal writing power determined through the OPC into the writing driver 32 (S31).

After the OPC, the microcomputer 36 reads position and

size information, which is recorded in the PMA, about recorded tracks (S32), and searches for the first lead-in area, the second, and the third, in turn based on the PMA information and chained information between lead-in areas (S33).

For example, supposed that tracks 1 and 2 belong to the first closed session, tracks 3 and 4 belong to the second closed session, and tracks 5 and 6 are recorded next to the second closed session as shown in FIG. 8, the microcomputer 36 reads out position information of the second lead-in area 'LIA2' from the first lead-in area 'LIA1', and knows next recording position, that is, the position of track 5 from the second lead-in area 'LIA2'. Since the program area containing the tracks 5 and 6 is not closed into a session (S34), the microcomputer 36 examines the PMA information to know how many tracks are recorded in the disk 1 and locates final recorded track based on the PMA information (S35).

However, if the PMA has wrong information of position and size about track 6 or has not since a servo control malfunctioned due to an external shock or a data buffer was underruned during recording the track 6, the microcomputer 36 considers the track 5, which was recorded normally, as the last one based on the PMA information although the track 6 has been formed in the disk 1 owing to partial recording.

To prepare for such an abnormal case, the microcomputer 36 does not write new data next to the track 5, instead, the microcomputer 36 controls the pickup 32 to reproduce from the ending point of the track 5 to a certain extent. Then, the microcomputer 36 checks whether the signals outputted from the R/F unit 33 are EFM-formatted binary signals (S37). If the output is binary signal of which state is toggled, the area following the track 5 is not blank, if not, it is blank.

If the area following the track 5 is blank, the microcomputer 36 returns the pickup 32 to the position which

is apart from the ending point of the track 5 by a pause section, and controls the pickup 32 to write new data from that position. However, if the area has pre-recorded data, the microcomputer 36 continues to check the reproduced signals until it is changed to constant, that is, not binary. So that, when the transition point at which the reproduced signal is changed from binary to constant is detected, the microcomputer 36 recognizes the transition point as an actual last point of recorded data belonging to uncompleted track 6 (S39).

After that, the microcomputer 36 closes the track 5 and the uncompleted track 6 into a session as writing necessary information in lead-in 'LIA3' and lead-out area 'LOA3' after securing the lead-out area 'LOA3' (S40), and it controls new data to be written in a program area as track 7 (S38) after the just-closed session, so that the new data is not overwritten in the uncompleted track 6.

Instead of closing the track 5 and the uncompleted track 6 in a session as above, the microcomputer 36 may secure a pause section just after the found last recording point, and then write new data next to the secured pause section as a track 7.

Some time later, if a session-close is requested, the microcomputer 36 closes tracks 5 and 7 and the uncompleted track 6 in a session, and writes necessary information in lead-in 'LIA3' and lead-out area 'LOA3' after securing the lead-out area 'LOA3'.

With the above-explained writing operation, an uncompleted track can be normally closed in a session and new data is never overwritten in an uncompleted track even though the PMA information is not same with tracks recorded actually in a program area.

Another example of recorded data is shown in FIG. 9 in which tracks 1 and 2 belong to the first closed session, tracks 3 and 4 belong to the second closed session, and tracks 5 and

6 are recorded next to the second closed session, and the position and size information about tracks 1 to 6 are written in the PMA, however the size of the last track 6 written in the PMA is not identical to the size of actually-recorded track 6 because of momentary buffer-underrun, etc. during recording the track 6.

A data writing method for the case of FIG. 9 is conducted as follows.

As explained above for the flow of FIG. 7, when a user requests new data to be recorded in an inserted disk 1, the microcomputer 36 sets its mode to recording mode, conducts the OPC, and sets an optimal writing power determined through the OPC into the writing driver 32. After the OPC, the microcomputer 36 reads position and size information, which is recorded in the PMA, about recorded tracks, and searches for the first lead-in area, the second, and the third, in turn based on the PMA information and chained information between lead-in areas. That is, the microcomputer 36 reads out position information of the second lead-in area 'LIA2' from the first lead-in area 'LIA1', and knows next recording position, i.e., the position of track 5 from the second lead-in area 'LIA2'. Since the program area containing the tracks 5 and 6 is not closed into a session, the microcomputer 36 examines the PMA information to know how many tracks are recorded and locates final recorded track, which will be track 6, based on the PMA information.

To resolve the abnormal case in which the PMA and actually-recorded track 6 are not same in size due to momentary buffer underrun etc., the microcomputer 36 does not write new data after the final recording position calculated based on the PMA information on the track 6, instead, it controls the pickup 32 to reproduce from the final position to a certain extent. Then, the microcomputer 36 checks whether the signal outputted from the R/F unit 33 is EFM-formatted binary signal. If the

output signal is binary, the area following the final position is not blank, if not, it is blank.

In the case that the area is not blank, when the reproduced signal makes transition from binary to constant, the microcomputer 36 recognizes the transition point as a substantial last point of the track 6, and closes an area from the starting point of the track 5 to the recognized last point in a session as writing necessary information in lead-in 'LIA3' and lead-out area 'LOA3' after securing the lead-out area 'LOA3'.

After that, the microcomputer 36 controls new data to be written in a program area as track 7 after the just-closed session, so that the new data is never overlapped partially with the track 6 of which recorded size is not identical to the size information of the PMA.

Another example of recorded data is shown in FIG. 10 in which tracks 1 and 2 belong to the first closed session, tracks 3 and 4 to the second closed session, and tracks 5 and 6 to the third session, and the position and size information about tracks 1 to 6 are normally written in the PMA, however the third lead-in area has wrong information on the next recording position or does not have it because of a mechanical shock or a buffer-underrun, etc. occurred during closing the third session. A data writing method for the case of FIG. 10 is conducted as follows.

As explained above for the procedure of FIG. 7, when a user requests new data to be recorded in an inserted disk 1, the microcomputer 36 sets its mode to recording mode, conducts the OPC, and sets an optimal writing power determined through the OPC into the writing driver 32. After the OPC, the microcomputer 36 reads out position information of the second lead-in area 'LIA2' from the first lead-in area 'LIA1', reads out position information of the third lead-in area 'LIA3' from

the second lead-in area 'LIA2', and tries to read out the next recording position for new data from the third lead-in area 'LIA3'.

However, the reading of the third lead-in area 'LIA3' fails due to abnormal recorded state which was made from a servo or writing fail caused by a mechanical shock, etc. Therefore, the microcomputer 36 controls the pickup 32 to reproduce from the starting point of the third program area next to the lead-in area 'LIA3', and checks whether the signal outputted from the R/F unit 33 is changed from EFM-formatted binary signal to constant signal. If the output signal is changed from binary to constant and the constant level maintains more than a pause period, the microcomputer 36 considers the changed position as an ending position of the track 6, i.e., the last track of the uncompleted session 3.

After detecting the actual recordable position, the microcomputer 36 secures the fourth lead-in area 'LIA4', and then controls new data to be written in a program area as track 7 (S38) after the secured lead-in area 'LIA4',

With the above-explained writing operation, new data is normally written in a blank area following the uncompleted session 3 even though the lead-in area of the uncompleted session 3 has abnormal data or has not position information on the next recording position.

In the above case that a lead-in area is invalid, a linking session may be created as shown in FIG. 11. The linking session contains one track of null data, a lead-in area whose information points the next recording position, that is, a lead-in area of new session 5 for new data, and a lead-out area.

Therefore, lead-in areas containing tracks which are recorded and closed in sessions normally are linked after the null session.

In the explained cases that the size of a track written